

An Oil Package Study aiming the Logistics Optimization on the Palletizing Capacity

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Abstract: The palletizing layout affects directly the company's costs and logistics efficiency, because with an optimal layout is possible to reduce the number of truck loading to meet the same demand. Therefore, this paper is a case study, showing the actual scenario of soybean oil manufacturing company, to propose a packaging study which will define the optimal dimensions for the package and palletizing. The reached results show a 25% pallet capacity increase, as well as a 25% reduction of the number of truck loading necessary to meet the demand.

Key words: Logistics, Optimization, Package.

1. Introduction

Adding value to the products is something that could be done in several perspectives, as price, consumer behavior and/or market strategy (Vilckas and Nantes, 2007). The logistics develops the role to improve the product quality focusing on the transportation and making the products meet the demand, being on the right place at the right time, and the transportation is characterized as the most representative element of its chain (Ballou, 2010).

According to the National Confederation of Transport (CNT, 2016), the road transportation in Brazil represents more than 60%, of all types of modals. In fact, the road transportation is considered an inefficient modal, because it offers to its products a negative impact, due to the occurrence of damages,

breakdowns, delays and other problems (Monaro *et al.*, 2015).

In order to reduce the handling time to transportation of the products or to minimize this kind of problem, it has being studied the unitization through the palletizing, which reduces the number of trips to deliver the same quantity of products and the number of volumes handled, offering less risks to damage the load (Ballou, 2010).

Furthermore, the main objective of this work is to maximize the capacity of the oil package palletizing on the studied company, consequently, improve the transportation by reducing the costs implied to it, showing all the results obtained on the proposed study and premises adopted to achieve the desired goal.

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2. Literature Review

According to Ballou (2010), the logistics involve a coordinated management of interrelated activities of several areas that compose an enterprise, such as finances, marketing, production/operations, in addition of the basic activities as transportation and storage. The author still indicates that the logistics resources when well applied and used may add more value to the product or service, attending better the final customers needs, and consequently, increasing the chances to improve the sales.

To Novaes (2007), the logistics add value of space/place, providing the product on ideal place to the client, time, related to the delivery time of the product or service, quality, including the delivery conditions of the product or service, and information, additional data about the product.

Thus, the logistics is directly influenced by the type of product transported, handled or stored. With this, knowing the context of the product development process is really relevant, as well as your package.

So the product development process is a set of activities that considers the technological restrictions, competitive and product strategies of the enterprise, to define product specifications to meet a certain demand (Rozenfeld and Forcellini, 2006). And is crucial to the enterprises survival, because it is a tool to identify the costumer's needs and determine market's opportunities (Cobra, 2012).

By that, the product development process is guided by goals that try to attend the market demand, satisfying the customers requirements and needs, at the same time that add value to the final product, hence achieving the business target (Baxter, 2003).

In this context, to elaborate this work, it was necessary understanding the conception of the product packages, as an important factor on the product development process, as described bellow.

An important step during the product development process is the creation of the packing, which has the basic functions as containing, protecting and facilitating the product transportation. However, over the years it also has been used to product conservation, exposition, selling and to consumer's communication and attraction (Mestriner, 2002a,b).

Besides that, the packing has impacts on the operation productivity and efficiency, because it affects the loading, storage and transportation of the products (Bowersox *et al.*, 2014).

Finally, the package is defined as a set of project and production activities of the container or wrap of a product, that creates a value to it, when well developed and implemented (Kotle and Keller, 2006).

3. Case Study

The enterprise studied is a manufacturer of soybean oil, which manufactures the product fully on your own installations.

So, basically the raw materials are treated and after the moisture is ready, it goes to the oil packaging area. The preform for the plastic bottles are blown, and then, filled with the oil on the same production line.

The preform and plastic bottles after being blowed are shown in the Figure 1.



Figure 1. Preform and actual package.

Table 1. Actual dimensions.

	1 unit	5 units	4 units
Package width	79 mm	395 mm	316 mm

The actual scenario is based on the actual package which has 249 mm high, 79 mm diameter and 900 mm volume. The secondary package contains 20 plastic bottles, arranged in a 5x4 layout, showed in Figure 2 and Table 1.

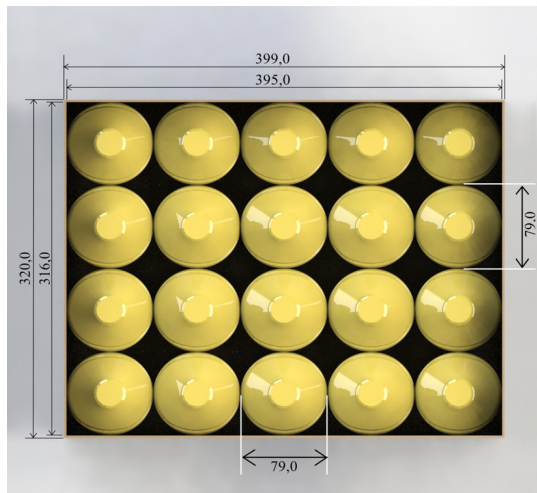


Figure 2. 5x4 layout arrange (source: Author, 2017).

The palletizing layout is shown in Figure 3, according to the pallet standard Brazilian dimensions, as 120 cm width and 100 cm length.

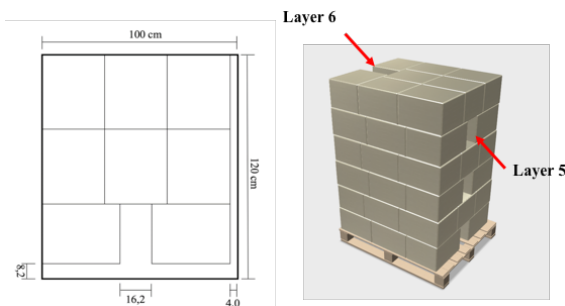


Figure 3. Actual palletizing layout (source: Author, 2017).

It is important to emphasize that the layers need to be braided, that is, the layout for each layer can't be the same, where the direction for the empty spaces alternates in the layers. Although it looks more simple, it was tested and showed bad results to resistance on the shacking.

So, the actual palletizing layout has capacity of 48 boxes, divided in six layers.

Also it is known that the transportation to the distribution centers is done by three types of trucks: two, three or four axles. Considering the pallet capacity in pallets and the weight for each pallet with the 48 boxes, indicated on the Table 2, it is possible to note that there is a considerable loading idleness, due the openings on the layout mentioned before. It means that part of the truck is empty during the

transportation, with 13%, 20% and 19% for the types of trucks, respectively.

Table 2. Actual dimensions.

	2 axles	3 axles	4 axles
Capacity (kg)	14,000	26,000	30,000
Boxes per pallet	48	48	48
Capacity (in pallets)	14	24	28
Load gross weight (kg)	12,125.7	20,768.9	24,251.4
Idleness (%)	13.39	20.05	19.16

Analysing the annual numbers, the company is capable of produces more than 8 millions of bottles per year. And approximately 30% of this is transported on the 2 axles trucks, around 65% on 3 axles trucks, and only 2% on the 4 axles type. So, comparing with the idleness for each type of truck, on the Table 3 is possible to see the amount of bottles that could be distributed in additional if the idleness were reduced.

Table 3. Idleness per truck in amount of bottles.

Axles	Idleness (%)	% per year	Annual production	Quantity
2	13.39	31.52		354,547
3	20.05	65.72	8,400,000	1,106,832
4	19.16	2.76		44,412

Therefore, due the empty spaces on the actual palletizing layout, more than 1.5 millions of bottles could be transported using the same amount of trucks, and with no additional costs, mainly with freight.

So the main problems found in the analyzed company are:

- i. Storage, moving and transportation idleness,
- ii. Stacking low resistance,
- iii. Product loss due to the damages in the boxes,
- iv. Damaged loading returns and loss of products for selling.

3.1. Restrictions

To propose a different arrange and layout, it is necessary analyze the company's restrictions.

In relation with the product, the shape is one of the factors that can not be changed, due the blowing

process line available. A change to a squared shape, for example, requires different and better raw materials and machines, then, the proposal may consider a cylinder shape for the new package.

Besides, looking to the logistics and trade aspects, it is important to verify the storage, transportation and distribution conditions, mainly due to the height of the bottle/package. On the logistics, it may affect the stock height of the customers and distribution centers, and for trade marketing, affects on the gondola heights.

4. Methodology

After that, it was verified the viability of the project implementation, the risks involved, and mechanical and financial factors affected by the package modification. Besides, due to the information from the company is calculated a representative payback.

The actual palletizing layout has several risks, because of the idleness there is low stacking resistance favoring the loads collapse, consequently is more likely that damages happen.

Then the mechanicals aspects are related with load transportation and movement. The main aim of the implementation is having a more resistant load stacking, which implies in an easier movement and a bigger stacking stability, optimizing the mechanical process.

Then, to check the project viability is necessary to verify the mechanical and financial factors affected. The mechanical aspects are related with load transportation and movement. The main aim of the implementation is having a more resistant load stacking, which implies in a easier movement and a bigger stacking stability, optimizing the mechanical process.

Due the company's privacy, the financial information as cost, revenue and profit, could not be revealed. So it was calculated a simple representative payback, getting that the bottles amount lost due to damages is approximately one million.

After that, it was possible to construct the problem modelling considering all the relevant information to the packaging. The first new information is about the height of the market racks equal to 26.2 cm, determined by the trade marketing department.

Besides, as a market requirement the packaging arrangement contains 20 bottles, organized as 5×4 units.

The secondary package is a cardboard box which has 2 mm thickness for each side of the box, summing 4 mm per box. Furthermore, to have a reasonable bottle diameter, each side of pallet can fit a maximum of 15 bottles. This, creates limitations of minimum and maximum diameter dimensions for the bottles, as 0.066 m and 0.079 m, respectively, due the standard measurements for the pallets in Brazil.

After collecting all the data, it is possible to make a packaging study to verify which are the optimal dimensions for this product. Basically, different palletizing layouts were proposed using the CAD software, trying to fit the largest amount of boxes for each layer on the pallet, considering the maximum and minimum limits and an interval of 3.25 mm, originating the five new scenarios. With the 5×4 units arrange, five units organized side by side indicate the width, and four units indicate the length of the package, as shown in Table 4.

Table 4. Possible layouts.

Axles	Idleness (%)	% per year	Annual production	Quantity
1	0.06600	0.334	0.268	0.090
2	0.06925	0.350	0.281	0.100
3	0.07250	0.367	0.294	0.108
4	0.07575	0.383	0.307	0.118
5	0.07900	0.399	0.320	0.128

According to the pallet size (1.2×1.0 m), it is known that its area is equal to 1.2 m². So, knowing the five scenarios dimensions, it is possible to calculate the optimal number of boxes that one palletizing layer could fit, that is, the biggest quantity of boxes that can be arranged in a layer, considering the area occupied by each scenario, as is presented on Table 5.

Table 5. Optimal quantities per scenario.

Scenario	Package area (m ²)	Pallet area (m ²)	Boxes per pallet layer
1	0.090		13
2	0.100		12
3	0.108	1.2	11
4	0.118		10
5	0.128		9

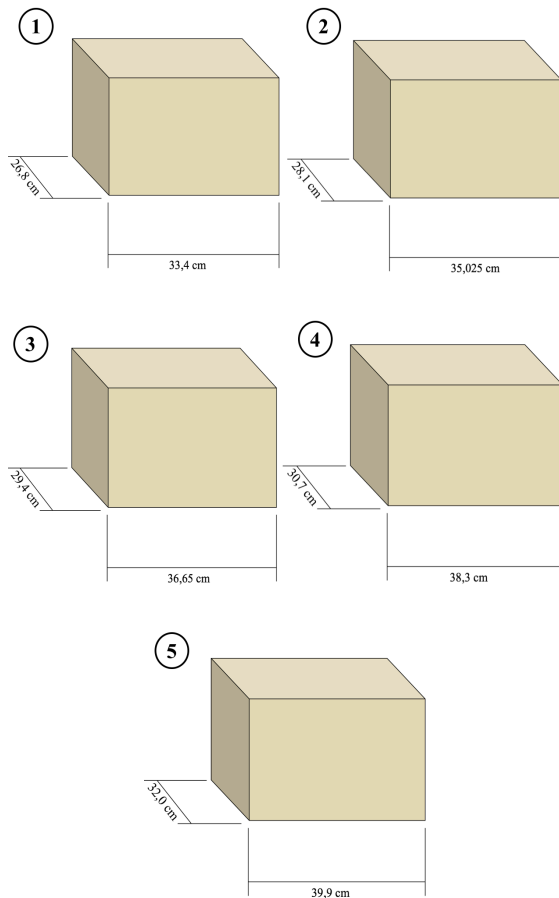


Figure 4. The five scenarios proposed.

However, since the arrange must be grouped in the 5×4 layout, it may infer a complication to fit this amount of boxes, existing the possibility do not reach it, due to the empty spaces among the boxes.

Another consideration is about the bottle volume, which must fit 900 mm. Thus, to find the volume, according to the height determined before as 26.2 cm, is considered the bottle as a cylinder. And to have an acceptable limit, it was defined that the cylinder has 1-liter volume, since part of the packaging goes empty, then it is found the minimum diameter that the bottle must have to fit this volume, which is 0.0697 m, discarding the scenarios 1 and 2. Besides, the scenario 5 has the same dimensions that the actual bottle, so it won't be analyzed.

5. Results

To have a considerable number of possibilities, it was proposed three arranges for each one of the five scenarios. Although it could be proposed more arranges, it was verified that most of them had the same quantity of boxes that the actual lay-out and bigger empty spaces, so it is shown only the three best arranges found.

Starting from the scenario 3, as illustrated on Figures 5, 6 and 7.

As discussed before, the optimal quantities do not imply in the real number of boxes fit on the pallet, as it possible to see in the arranges 1 and 2, for scenario 3, as the expectation was to have eleven boxes for each layer, fitting only ten. And the arrange 2 has the big right-side space, which may compromise the stacking, while the number 3 present measurements out of the pallet, remaining only the first one.

Similarly, the scenario 4 was arranged, as shown in the Figure 8, 9 and 10.

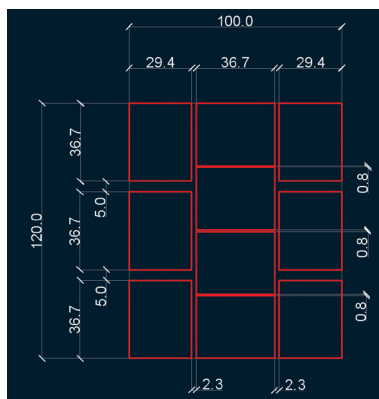


Figure 5. Scenario 3, arrange 1 (source: Author, 2017).

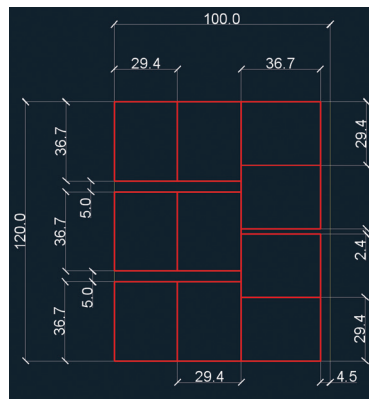


Figure 6. Scenario 3, arrange 2 (source: Author, 2017).

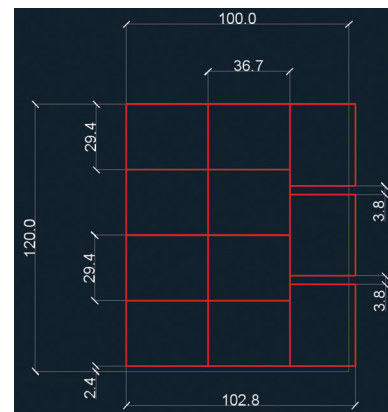


Figure 7. Scenario 3, arrange 3 (source: Author, 2017).

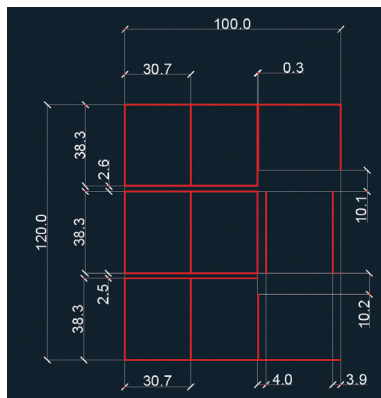


Figure 8. Scenario 4, arrange 1 (source: Author, 2017).

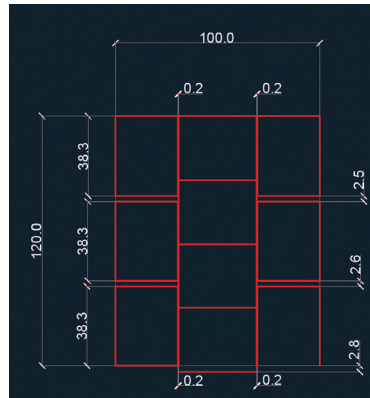


Figure 9. Scenario 4, arrange 2 (source: Author, 2017).

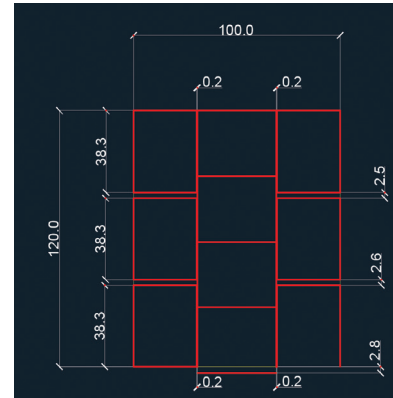


Figure 10. Scenario 4, arrange 1 (source: Author, 2017).

As well as the last scenario, the arranges 1 and 3 fit only nine boxes, which is the same quantity of the actual palletizing layout, not presenting any efficiency improvement. Besides, the arrange 2 has bigger dimensions than the pallet.

So from the six arranges, only one was left. To have more satisfactory results, it became necessary to analyze more scenarios. Then, due to the elimination of scenario 4, 1 and 2 were discarded because they could not fit the volume required, it was defined more scenarios between 3 and 4, as shown in the following Table 6.

Table 6. New scenarios.

Scenario	Diameter (m)	Area	Boxer per pallet layer
3	0.0725	0.108	11
6	0.0736	0.111	10
7	0.0747	0.114	10
4	0.07575	0.118	10

Similarly to the previous scenarios, it was analyzed the possible arranges for the two new scenarios, with three possible layouts tested, showed on Figures 11, 12 and 13.

It is possible to verify the big empty spaces on the arrange 2, implying in serious problems to stack the layers, discarding it, and remaining the arranges 1 and 3.

The last one, the scenario 7 is also shown in the Figures 14, 15 and 16.

Once again, the arrange 1 has remaining dimensions, so it is discarded. The others arrange fit only nine boxes, the same quantity for the actual palletizing layout, implying in the elimination of all arranges in the scenario 7.

The three remaining possibilities are originated from the scenario 3, 6 and 6 again, with the arranges 1,

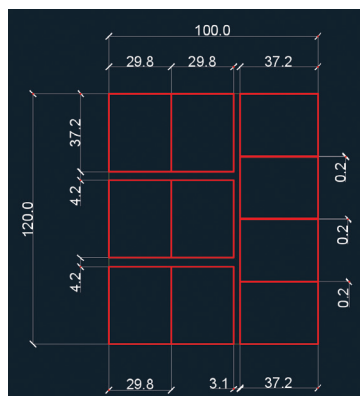


Figure 11. Scenario 6, arrange 1 (source: Author, 2017).

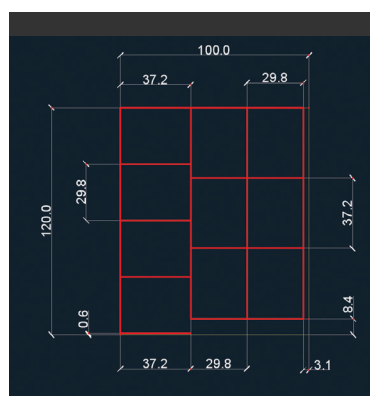


Figure 12. Scenario 6, arrange 2 (source: Author, 2017).

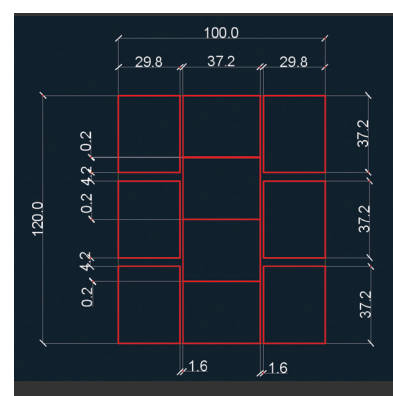


Figure 13. Scenario 6, arrange 3 (source: Author, 2017).

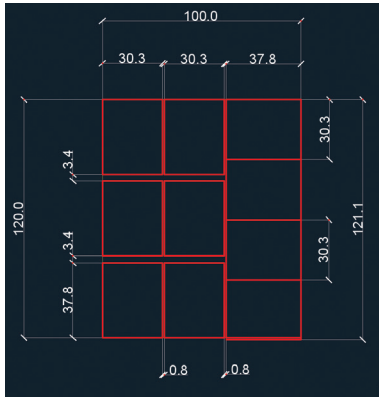


Figure 14. Scenario 7, arrange 1 (source: Author, 2017).

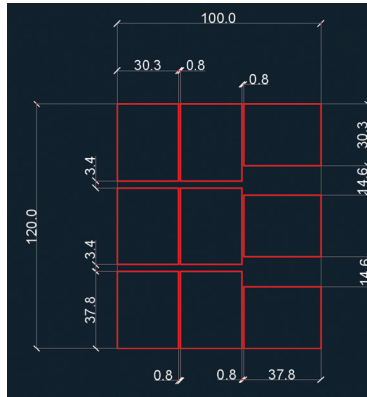


Figure 15. Scenario 7, arrange 2 (source: Author, 2017).

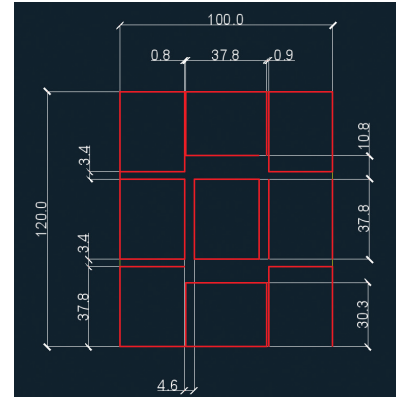


Figure 16. Scenario 7, arrange 3 (source: Author, 2017).

1 and 3, respectively, and all of them has the capacity of 200 bottles per layer, or 10 boxes, stacking 60 boxes in the layout. The proposed scenarios are shown on Table 7 and Figures 17, 18 and 19.

As the goal of this work as minimize the idleness, it was verified the available area on each layer, by calculating the available area on the pallet subtracting the area occupied by the packages, with

0.12 m² for the first option and 0.09 m² for the others two, eliminating the first arrange from scenario 3, and remaining the others two.

From the two left options, both has the same occupied area and contain the same number of boxes per layer on the palletizing layout, however, the arrange 3, from scenario 6, presents a layout that could not be braided, which is necessary, meaning

Table 7. Analyzed arranges follow-up.

	Diameter (m)	Status	Reason
1	0.06600	Discarded	Smaller dimensions than the minimum radius to fit 1 liter volume
2	0.06925	Discarded	
3	0.07250	1 arrange	-
4	0.07575	Discarded	The arranges have dimensions out of the pallet or fit the same quantity of boxes per layer of the actual layout
5	0.07900	Discarded	Actual bottle dimensions
6	0.07360	2 arranges	-
7	0.07470	Discarded	The arranges have dimensions out of the pallet or fit the same quantity of boxes per layer of the actual layout

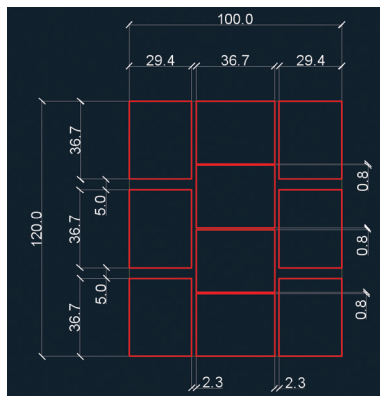


Figure 17. Scenario 3, arrange 1 (source: author, 2017).

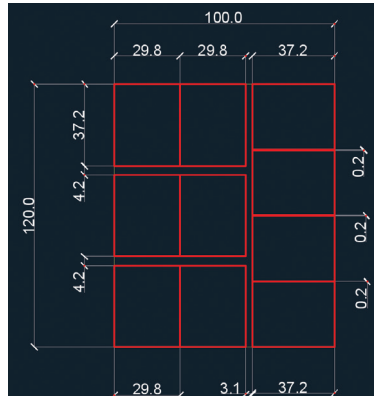


Figure 18. Scenario 6, arrange 1 (source: author, 2017).

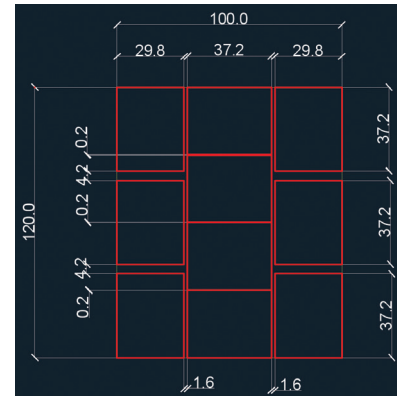


Figure 19. Scenario 6, arrange 3 (source: author, 2017).

that all the layers have the same layout, not inverting the direction of the boxes, and it highly compromises the resistance of the stacking, as already mentioned before.

Therefore, the arrange chosen is the option 2, from scenario 6 on the proposed arrange 1, showed in the Figure 20.

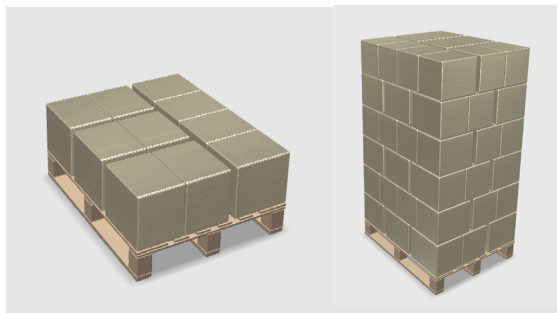


Figure 20. New pallet layout.

The optimal size or diameter for the bottle is equal 0.0735 m. And considering the occupied area on the palletizing layout, according with the dimensions of pallet layer, the idleness is less than 8.5%.

Then, the new pallet layout fits 60 boxes, or 10 boxes in each one of the six layers. Compared with the actual scenario, it represents an increase of 25% on the capacity of only one pallet. It means that on the transportation of one single pallet, there is a gain of 12 boxes or 240 bottles if used the new pallet layout proposed. The information is represented on Table 8.

Table 8. Proposed arrange information for each type of truck.

Scenario	2 axles	3 axles	4 axles
Bottles per box	20	20	20
Boxes per pallet	60	60	60
Pallet gross weight (kg)	1,073.9	1,073.9	1,073.9
Capacity (in pallets)	13	24	27
Load gross weight (kg)	13,960.7	25,772.6	28,995.3
Idleness (%)	0.29	0.87	3.35

Finally, the improvements of the palletizing optimization are analyzed, showing the positive results, as well as the numbers for the idleness to the proposed layout. The data shown in Table 2 is now updated in Table 8. It is possible to notice that several factors were optimized due the modification on the bottle dimensions.

Table 9. Comparison of the actual layout and the proposed using the demand met for 2015.

Scenario	2 axles		3 axles		4 axles	
Boxes transported	672	780	1,152	1,440	1,344	1,620
Gain (%)	-	16.07	-	25	-	20.53
Loads	1,485	1,280	1,806	1,445	65	54
Reduction (%)	-	13.8	-	19.99	-	16.92

Using the demand numbers met in 2015 for the production of the oil, it is calculated how many trips would be necessary to meet the same demand with the proposed layout. Since the numbers of boxes per pallet is higher, it is expected that the numbers of trips are smaller, obtaining a positive result for all of the three types of transportation, as shown in Table 9.

The first improvement is about the boxes per pallet which had an increase of 25%, having the capacity of 60 boxes compared to the 48 in the actual layout. With this, the loading capacity of the trucks is also expanded, reaching 13, 24 and 27 pallets per load for the two, three and four axles, respectively.

Consequently, the loading idleness is reduced too. In the old layout, the idleness was 13% for the two axles trucks, 20% for the three axles and 19% for the four axles. Implementing the proposal, it could change drastically the idleness, getting 0.29% for two axles, 0.87% for three axles and 3.35% for four axles.

The numbers show that the proposal has a gain of 16% for the two axles trucks, 25% for the three axles and 20% for the four axles. At the same time, it reduces the number of loadings necessary, reaching 13%, 20% and 16% respectively. It means that is necessary less trips to meet the same demand met in 2015, since it is possible to transport more boxes per pallet, when compared with the actual layout.

6. Conclusion

The proposed study resulted in an increase of 25% on the pallet capacity, where the old layout fit 48 boxes, or 960 bottles, and with the implementation of the proposal, the new palletizing layout would fit 60 boxes, or 1,200 bottles.

Besides, the logistic idleness when using the actual palletizing layout represents 13.39% of the truck with 2 axles, 20.05% for trucks with 3 axles and,

finally 19.16% for those trucks with 4 axles. Then, with the proposed layout, the idleness values became 0.29%, 0.87% and 3.35%, respectively for the types of trucks mentioned.

Consequently, considering the demand met on 2015, there was a gain of 16.07% of the quantity fit on the pallets loading for the trucks with 2 axles, 25% for those with 3 axles, and 20.53% for the 4 axles. It indicates that the implementation would bring to the company an increase from 672 to 780 boxes for 2 axles truck, 1,152 to 1,440 boxes to 3 axles, and 1,344 to 1,620 boxes for 4 axles.

Thus, to met the demand were necessary 1,485, 1,806 and 65 loads for the 2 axles, 3 axles and 4 axles trucks, respectively. So, after the implementation, the number of loads to met the same demand would be reduced to 1,280, 1,445 and 54, for the same types of trucks, respectively, showing a significant reduction on the quantity of trips that the trucks should do to met the costumers needs in 2015.

Besides, it is possible to reduce the idleness on the palletizing layout, which currently is equal to 14.88%. With the improvement it would be increased to 7.5%, which means that, previously, analyzing the occupied volume for the six layers on pallet, approximately 15% represented empty spaces, while with the proposed layout would turn out to be only

7.5%, because the layout can not fir all the space available on the truck, as explained before.

With a smaller area empty or idle on the proposed palletizing layout, there is a better stacking during the transportation and storage too, because there is less idle spaces among the boxes on the layers, it results on less damaged loads or products during the transportation or storage.

Besides, it was shown a considerable gain in the logistics efficiency, this is because it will be necessary a smaller number of shipments of loads to meet the requested demand, and the company will be able to deliver that in a shorter period, compared with the actual palletizing layout and transportation characteristics.

In summary, for all types of trucks, the proposal had really positive numbers in idleness, number of trips to meet the demand, quantity of boxes per pallet, amount of boxes transported, and several another benefits could be noticed.

Finally, the results show that the study does not works only for the oil bottles, but for all similar-shape packages, being useful for any kind of product, since it was presented all the information necessary to a package study.

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